

# What can the UW do for the DOE CC program?

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# Guidelines for University Presenters

- ◆ The goal of this workshop is to identify the developments that are necessary to enable the fabrication of long-length coated conductors with good performance. **The purpose of this session is to show how the research programs and facilities at universities can be applied toward that goal.**
- ◆ Your talk should focus on how the research and facilities at your university can help meet the goal of producing long-length conductors with good performance. During your talk, please try to address the following questions: **How does your research apply to the on-going efforts at the national laboratories and in industry? Does your research apply to one specific process or is it broadly applicable to the various processes for producing coated conductors? Are there new ideas or directions that should be pursued? If so, how will these new ideas assist our efforts to reach our goal?**
- ◆ Other topics that you should consider and be prepared to discuss, but which should not be the focus of your talk, include: How would proprietary information be handled? **Would public disclosure of information through publications and presentations be a necessity? Are there opportunities to combine our efforts with those sponsored by other agencies, e.g. the Air Force?**

# Motivating Interests

- ◆ Film growth by chemical and PVD routes
- ◆ Theory coupled to experiment
- ◆ Advanced superconducting and microstructural characterizations
- ◆ Conductors, their stability and protection
  - Metallic buffers
  - Interface resistance YBCO/stabilizer
- ◆ Collaborations

# Thickness Dependence of $J_c(H)$

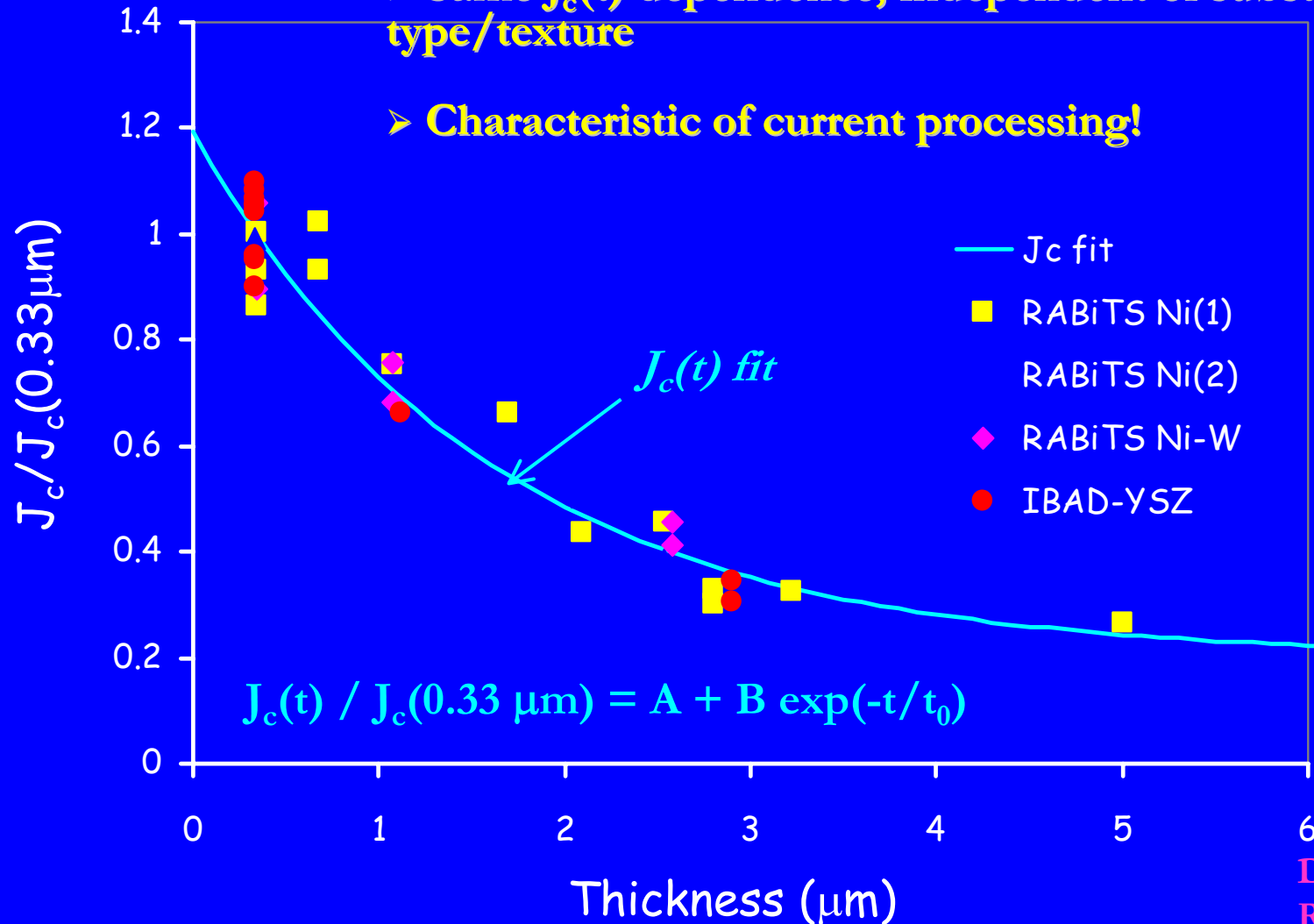
- ◆ November 2001 visit to ANL, LANL and ORNL (Oberly, Weinstock, Larbalestier) to find out key issues
- ◆ Much in hand -  $J_c(t)$  not
- ◆ Organized 2 hr meeting at St Pete 2002
- ◆ Nucleated 3 MURI experimental efforts to amplify earlier LANL study
  - Addition of theory component (Gurevich)

# $J_c(t)$ dependence in $\text{BaF}_2$ YBCO - variable $t$ films

➤ Normalization compensates for texture/substrate effects

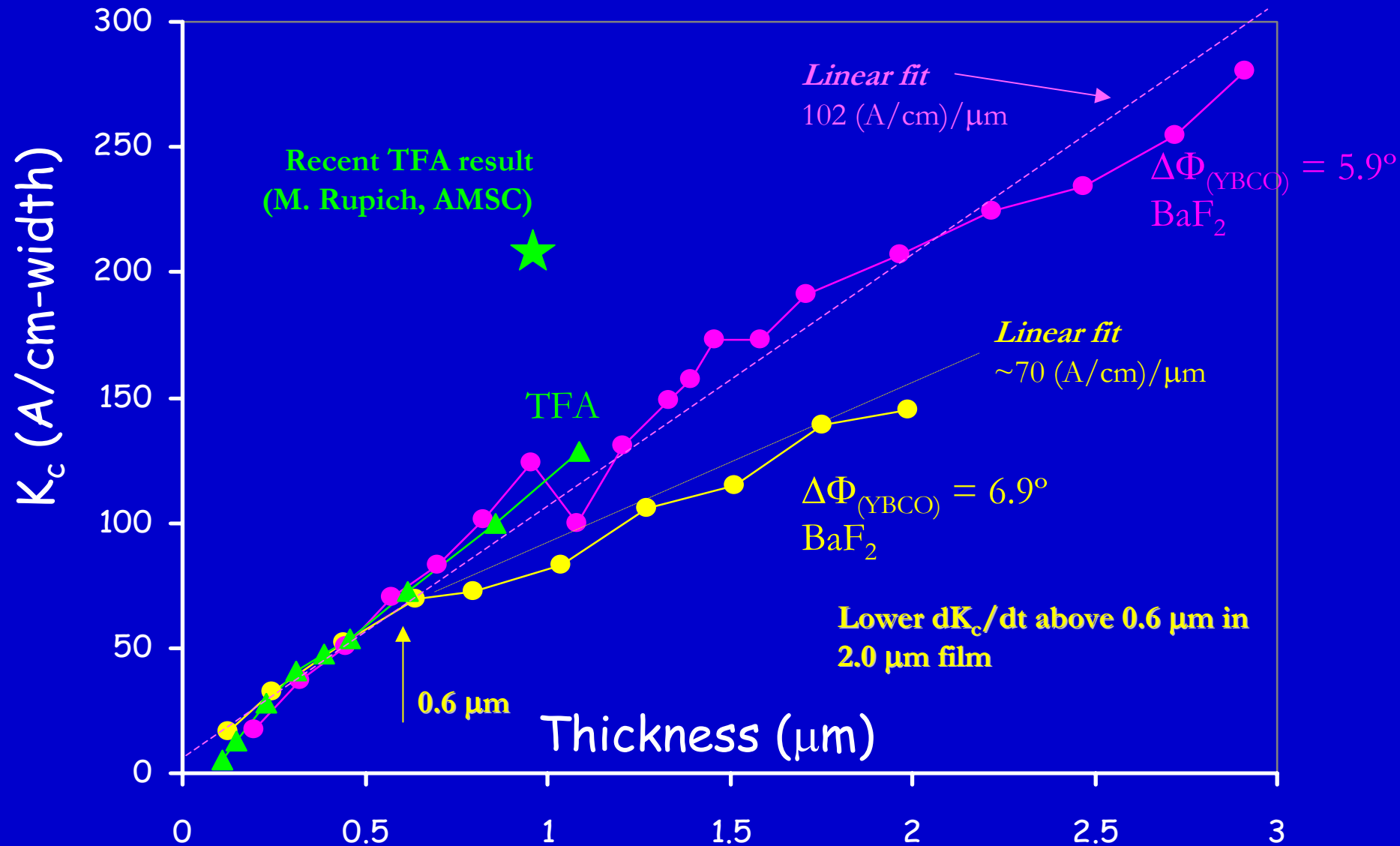
➤ Same  $J_c(t)$  dependence, independent of substrate type/texture

➤ Characteristic of current processing!



Data courtesy of  
R. Feenstra, ORNL

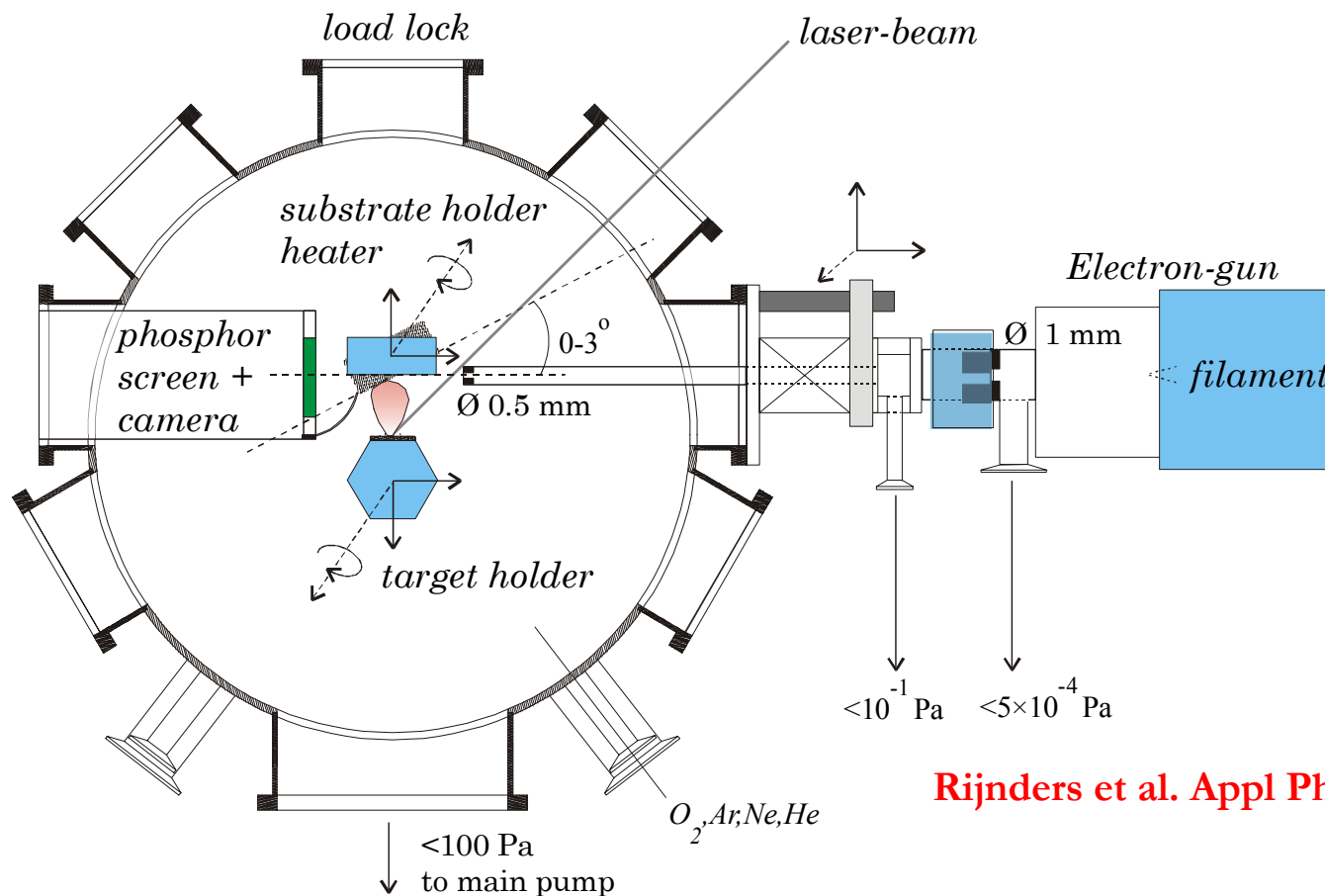
# Through thickness milling experiments shows ~ linear dependence of $I_c$ on $t$



# Jc(t) experiment

- ◆ Done on 2 ex situ CC
  - BaF<sub>2</sub> on IBAD-YSZ
  - MOD on RABiTS Ni-W
- ◆ Both show quasi-linear dependence of Ic on t
  - Very good news for high current conductors
  - Physics limit  $I_c \propto t^{0.5}$  not yet met (?)
- ◆ BUT...
  - Jc is constant at ~1MA/cm<sup>2</sup>, even at 0.3 μm, not 3 MA/cm<sup>2</sup>
- ◆ Epitaxy of growth may be crucial, especially disruptions at cap-YBCO interface
- ◆ Transport magneto-optics to be added to through-thickness milled samples

# Pulsed Laser Deposition System with *in situ* High Pressure RHEED



Rijnders et al. Appl Phys. Lett. 70 (1997) 1888

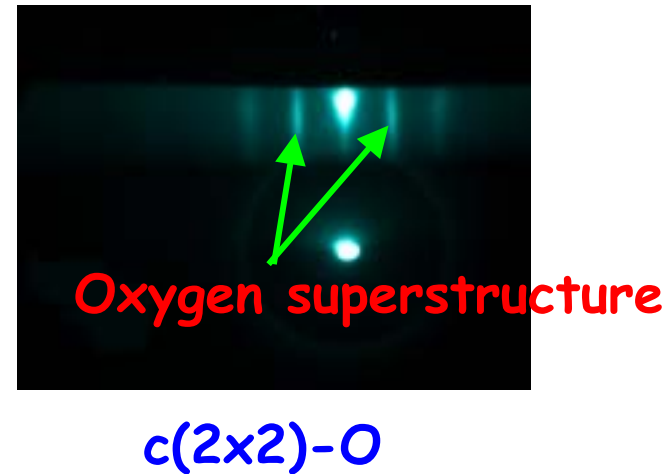
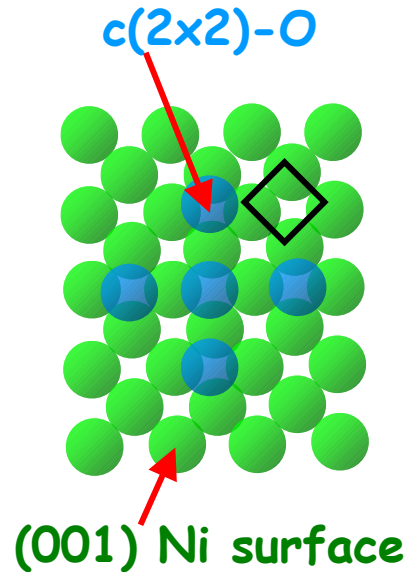
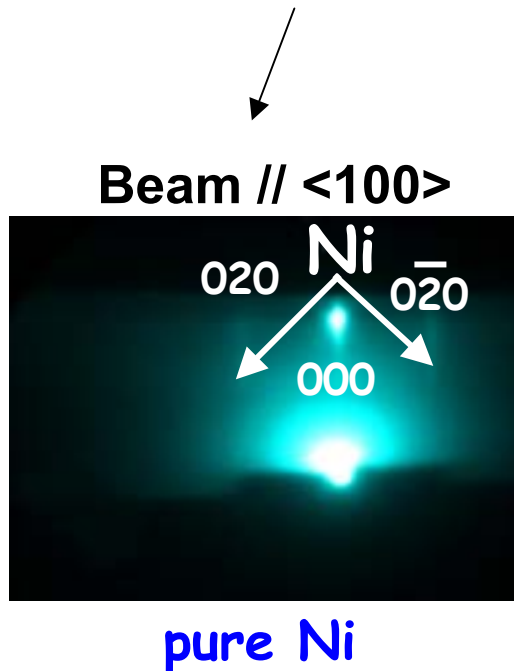
We used this system to monitor the oxygen  $c(2 \times 2)$  reconstructed surface and deposit epitaxial  $\text{SrTiO}_3$  buffer layer and YBCO superconductor.

Works up to 1 Torr  $\text{O}_2$

Eom group

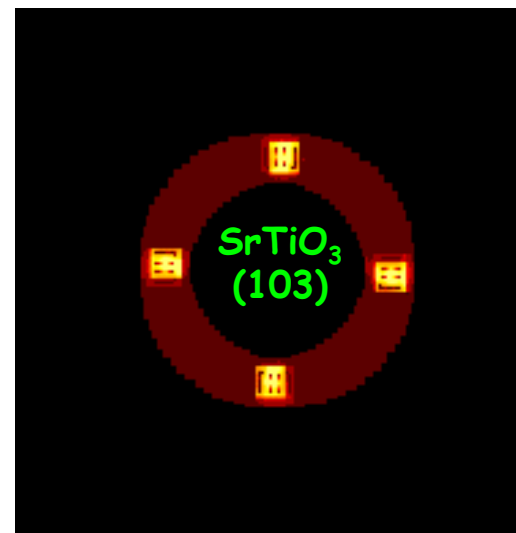
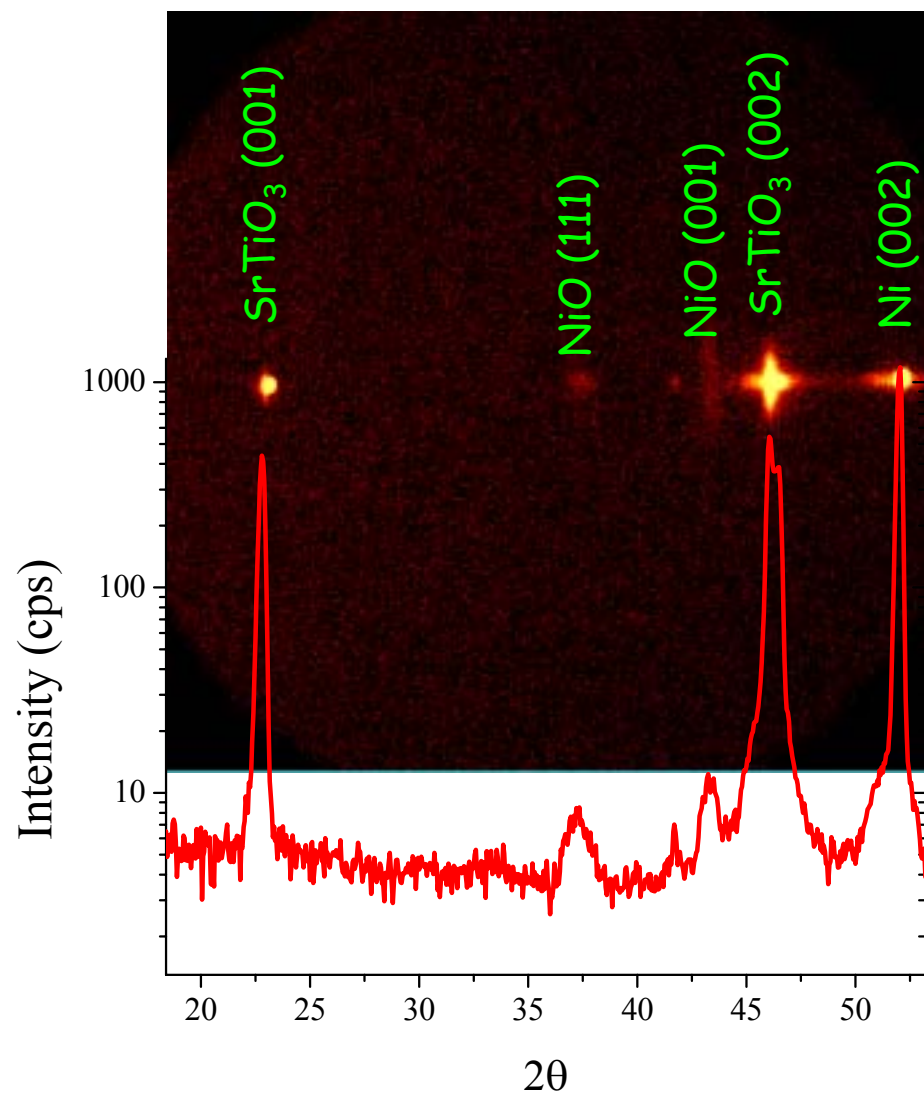
## c(2x2)-Oxygen superstructure

Pure Ni surface without  
c(2x2) superstructure



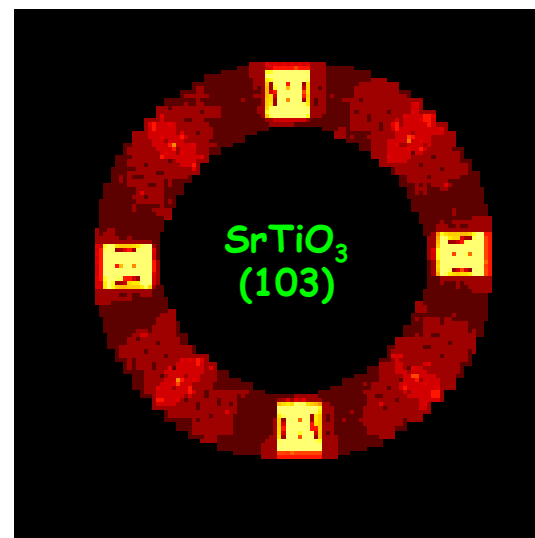
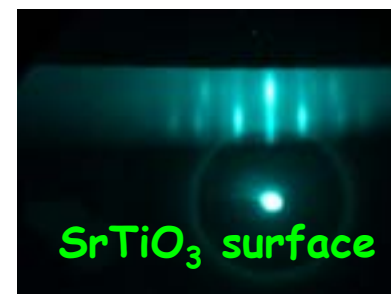
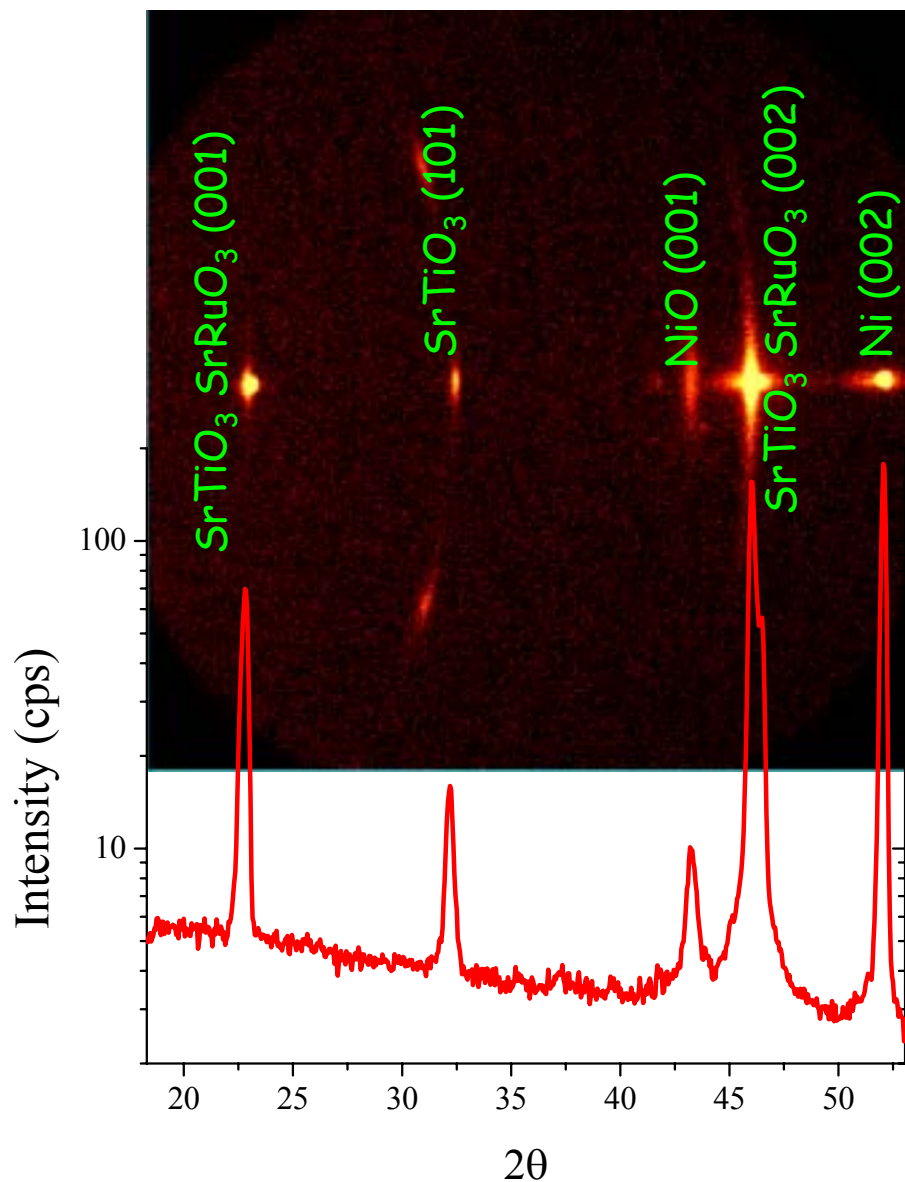
We were able to grow epitaxial  $\text{SrTiO}_3$   
buffer layer only on this surface but not on pure Ni.  
- See next view graph.

$\text{SrTiO}_3$  layer deposited on Ni with  $c(2 \times 2)$ -oxygen superstructure shows perfect epitaxy

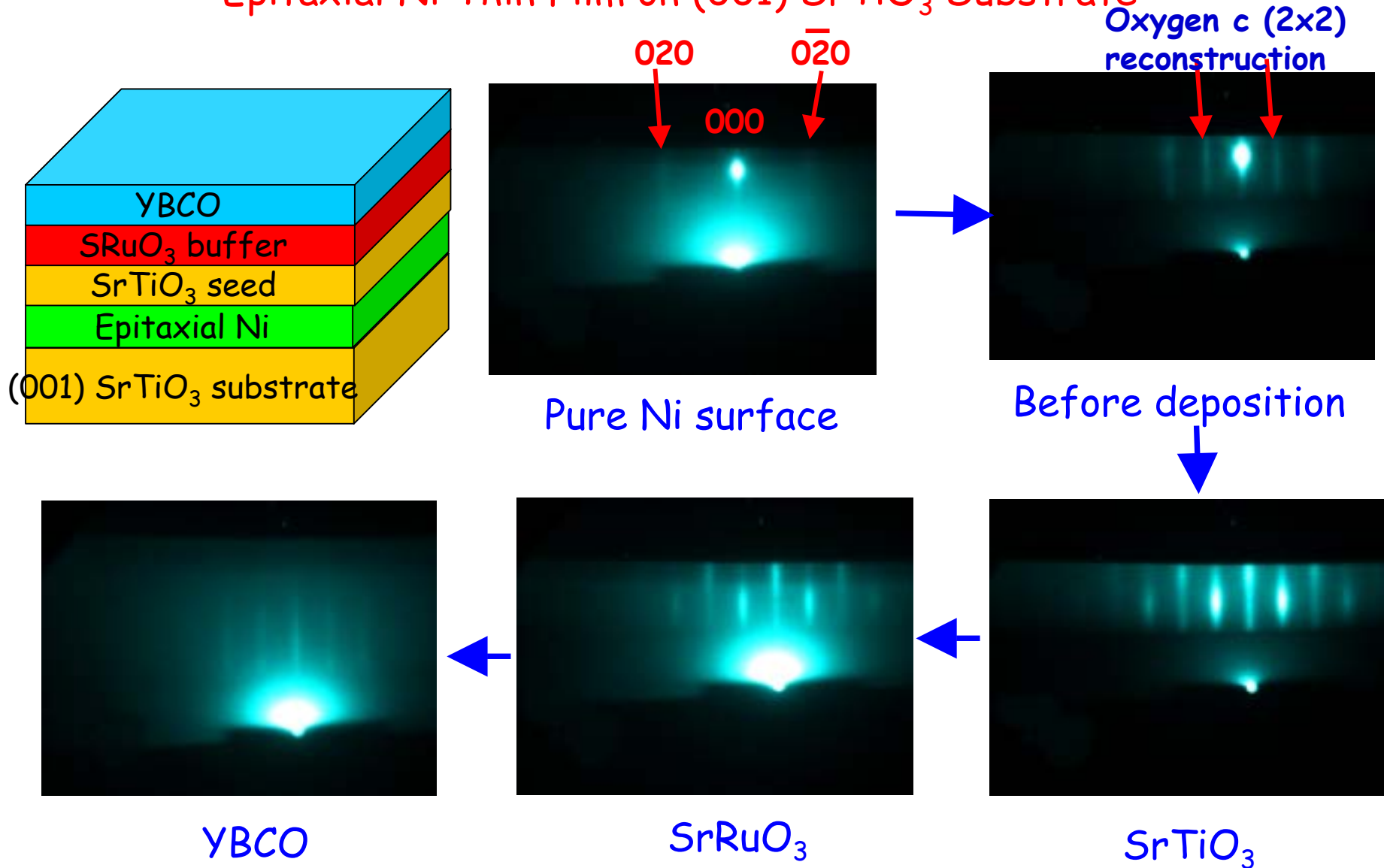


In contrast,

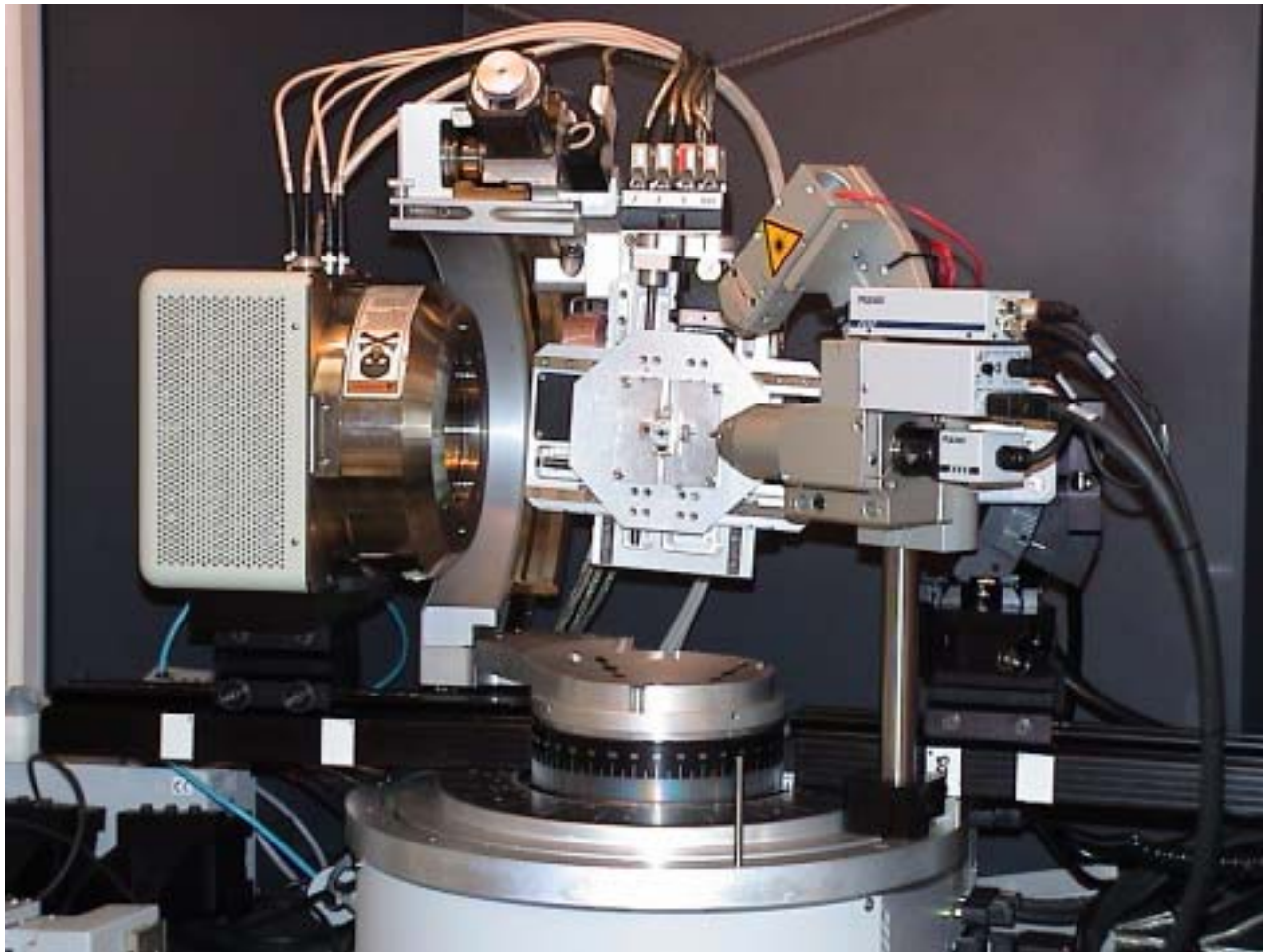
$\text{SrTiO}_3$  layer deposited on pure Ni without  $c(2 \times 2)$ -oxygen shows bad texture



# RHEED patterns during the growth of epitaxial YBCO/SrRuO<sub>3</sub>/SrTiO<sub>3</sub> on Epitaxial Ni Thin Film on (001) SrTiO<sub>3</sub> Substrate

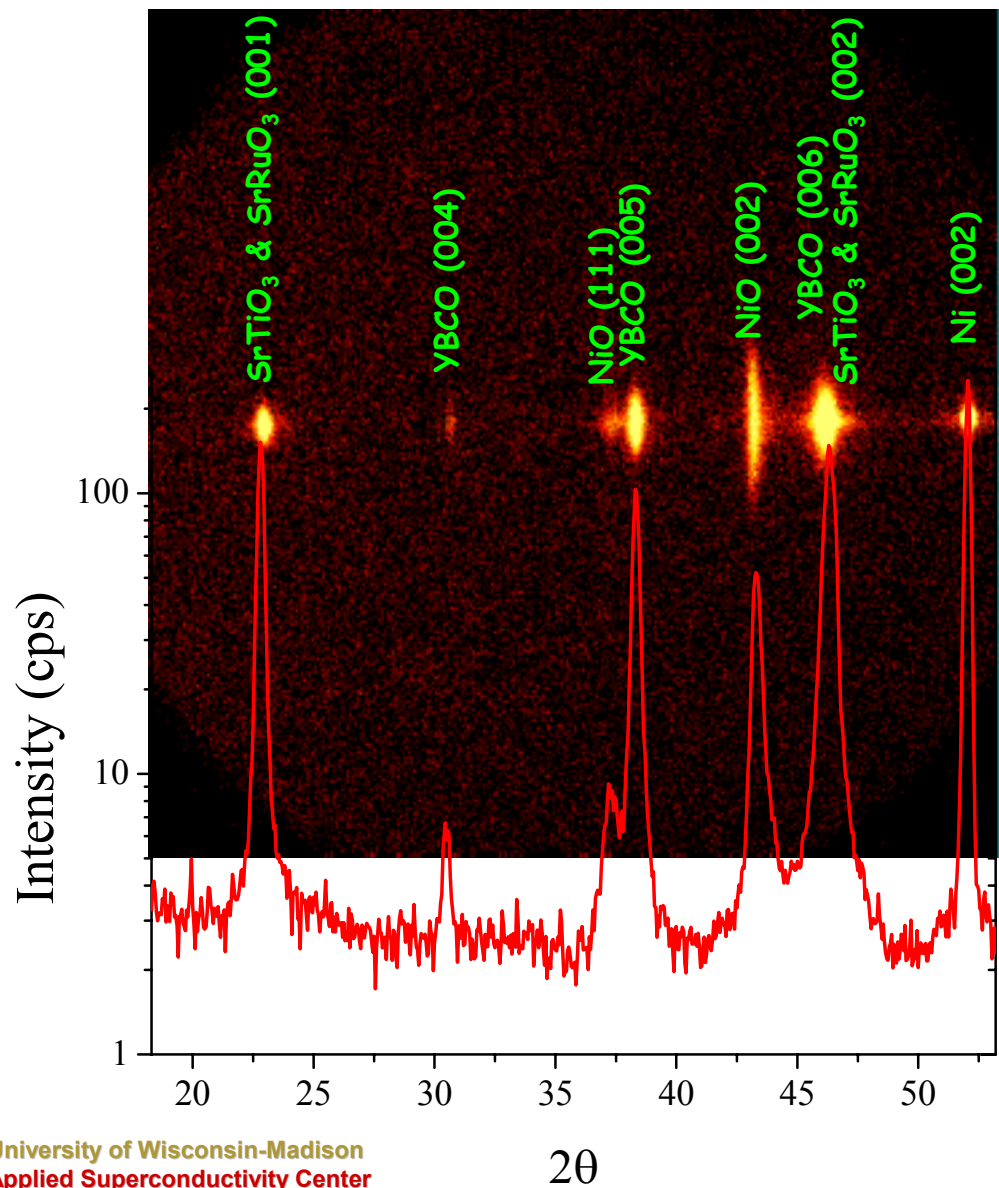


Variable Temperature (6.5K - 900C)  
Four-circle x-ray diffraction system with 2-D area detector  
Microdiffraction - 50 microns



Eom group

Texture of YBCO/SrRuO<sub>3</sub>/SrTiO<sub>3</sub> on epitaxial Ni  
studied by x-ray diffraction - This shows perfect epitaxy of all three layers



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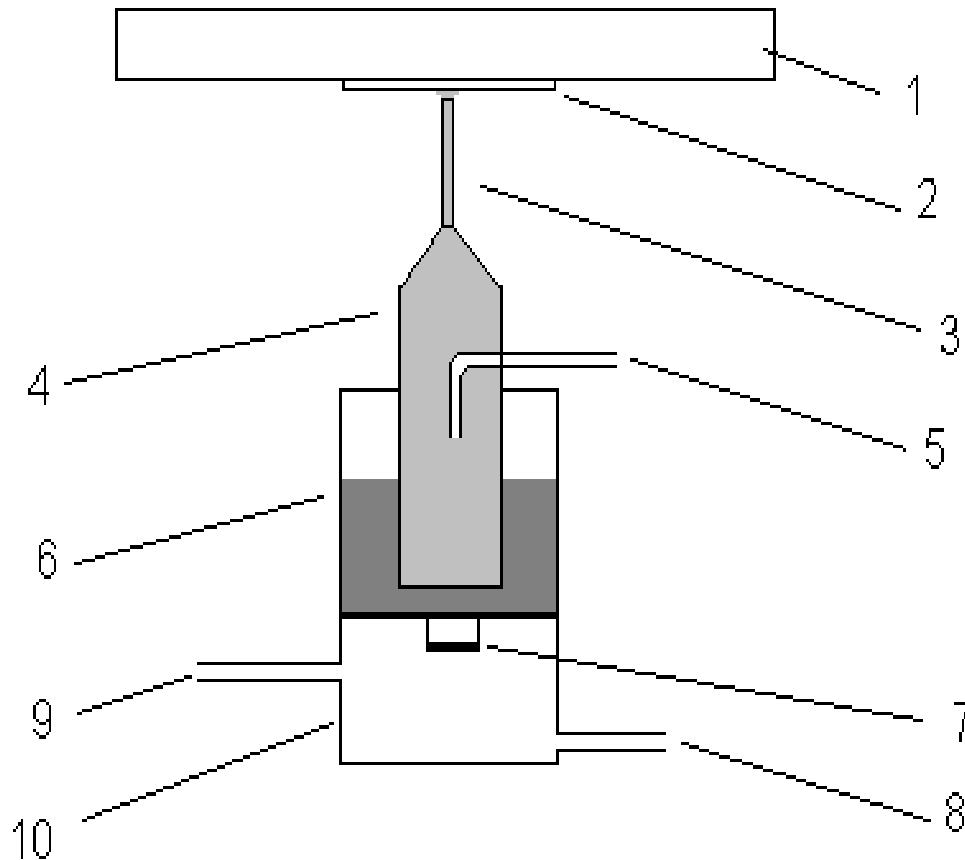


In-plane Pole Figure

# Aerosol Spray Pyrolysis (ASP) of oxide layers - buffers and Y-123

- ◆ Inexpensive, rapid solution method to form epitaxial oxide layers
- ◆ Spray mist ( $\sim 5\mu\text{m}$  droplets) of solution onto heated substrate ( $\sim 900^\circ\text{C}$ )
- ◆ Oxide forms directly on heated substrate

# ASP system is simple, inexpensive, and operates at atmospheric pressure



1. Resistive heating plate
2. Substrate
3. Quartz nozzle
4. Mist chamber
5. Carrier gas inlet
6. Solution tank
7. Transducer
8. Cooling water inlet
9. Cooling water outlet
10. Cooling tank

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# Benefits of ASP

- ◆ Deposit simple or complicated oxides -  $\text{CeO}_2$  to Y-123
  - Change chemistry during deposition
- ◆ Inexpensive solutions
  - from metals, oxides, nitrates, carbonates, or acetates
- ◆ Rapid - 17nm/s
  - Reducing conditions for buffers
  - Oxidizing conditions for Re-123

# Two European groups doing ASP

- ◆ F. Weiss - St. Martin d'Hères, France
  - \*  $\text{Y}_2\text{O}_3$  buffer layer on LAO
  - \* Y-123 on Ag
  - \* (Hg,Re)-1223 on MgO
- ◆ J. MacManus-Driscoll, Imperial College
  - Y-123 on LAO, MgO, and Ag
- ◆ No reports of buffer or Y-123 on Ni (or Cu) substrate

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# Summary - what can we offer?

- ◆ Certain unique capabilities
  - PLD chamber with high pressure RHEED
  - ASP capability for whole stack growth
  - Modeling from deep understanding of solid state *and* conductor stability
  - Broad *and* deep superconducting and microstructural characterization capabilities - nV V-I, magneto optics, scanning laser microscopy forthcoming, high resolution microscopy
- ◆ Applicability to RABiTS, IBAD and other CC
- ◆ Multidisciplinary and highly interactive
  - With each other and with the labs, industry and MURI partners
  - We enjoy this!